ORAL ARGUMENT NOT YET SCHEDULED

Case No. 24–1120 (and consolidated cases)

IN THE UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

STATE OF WEST VIRGINIA, *et al.*,
Petitioners,
v.
U.S. ENVIRONMENTAL PROTECTION AGENCY, *et al.,*
Respondents.

On Petitions for Review of Final Action by the
United States Environmental Protection Agency
89 Fed. Reg. 39,798 (May 9, 2024)

FINAL BRIEF OF *AMICI CURIAE* GRID EXPERTS RIC O'CONNELL, BRENDAN PIERPONT, BENJAMIN F. HOBBS, JESSE JENKINS, BRENDAN KIRBY, KENNETH J. LUTZ, MICHAEL MILLIGAN, MICHAEL O'BOYLE, and MATTHEW SCHUERGER IN SUPPORT OF RESPONDENTS

DENISE GRAB
RUTH LAZENBY
Frank G. Wells Environmental Law Clinic
UCLA School of Law
405 Hilgard Avenue
Los Angeles, CA 90095
Tel: (310) 206-4033
grab@law.ucla.edu

Counsel for Amici Curiae

November 7, 2024

CERTIFICATE AS TO PARTIES, RULINGS, AND RELATED CASES

I. Parties and *Amici*

Except for the following, all parties, intervenors, and *amici curiae* appearing before this Court are listed in the Opening Brief for Petitioners, ECF No. 2073644 (filed Sept. 6, 2024): *Amici Curiae* in Support of Petitioners Electric Reliability Council of Texas, Inc., Midcontinent Independent System Operator, Inc., PJM Interconnection, L.L.C., and Southwest Power Pool, Inc. ("Regional Transmission Organization *Amici*" or "RTO-*Amici*"); and *Amici Curiae* in Support of Respondents Ric O'Connell, Brendan Pierpont, Benjamin F. Hobbs, Jesse Jenkins, Brendan Kirby, Kenneth J. Lutz, Michael Milligan, Michael O'Boyle and Matthew Schuerger ("Grid Expert *Amici*" or "*Amici*").

II. Rulings Under Review

These consolidated cases involve petitions to review the U.S. Environmental Protection Agency's final action entitled "New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal

of the Affordable Clean Energy Rule," published at 89 Fed. Reg. 39,798 (May 9, 2024) (the "Rule").

III. Related Cases

To the best of counsel's knowledge, all cases challenging the Rule have been consolidated in this proceeding, and there are no other related cases within the meaning of D.C. Cir. R. 28(a)(1)(C).

RULE 29 STATEMENTS

Amici certify that no party in these consolidated proceedings has objected to the filing of this amicus brief.

Pursuant to Fed. R. App. P. 29(a)(4)(E), undersigned counsel for *Amici* states that no party or party's counsel authored this brief in whole or in part, and no other person besides *Amici* or their counsel contributed money intended to fund preparing or submitting the brief. We note that *Amici* Ric O'Connell, Michael O'Boyle and Brendan Pierpont filed a declaration in support of Public Health and Environmental Respondent-Intervenors Opposition to the Stay, but no party or party's counsel authored this brief in whole or in part, and *Amici* were not paid for their declaration or this brief.

Pursuant to D.C. Cir. R. 29(d), undersigned counsel for *Amici* state that a separate brief is necessary due to *Amici*'s distinct expertise and interests. *Amici* are engineers and analysts with expertise in the operation, structure, economics, regulation, and reliability of the U.S. power system. No other *amici curiae* appearing in this case share these perspectives or expertise, as far as *Amici* are aware. Accordingly, *Amici*, through counsel, certify that filing a joint brief would not be practicable.

/s/ Denise Grab
DENISE GRAB
November 7, 2024

TABLE OF CONTENTS

TABLE OF AUTHORITIES

STATUTES

REGULATIONS

OTHER AUTHORITIES

GLOSSARY OF ABBREVIATIONS

EGU	Electric generating unit
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
GW	gigawatt
IPM	Integrated Planning Model
ISO	Independent System Operator
MISO	Midcontinent Independent System Operator
MWh	megawatt hour
NERC	North American Electric Reliability Corporation
NREL	National Renewable Energy Laboratory
PJM	PJM Interconnection, LLC
RTO	Regional Transmission Organization
RULOF	Remaining Useful Life and Other Factors
SPP	Southwest Power Pool
The Rule	New Source Performance Standards for Greenhouse Gas Emissions from New and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emissions Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule

AMICI CURIAE'S STATEMENT OF IDENTITY, INTEREST IN CASE, AND SOURCE OF AUTHORITY TO FILE

Amici are among the nation's leading engineers and analysts with expertise in the operation, regulation, and reliability of the U.S. power system.[1] They have expertise in grid structure, operations, economics, and modernization; integration of renewable energy generation; and power-system reliability and planning. *Amici* have a significant interest in the efficient functioning and regulation of the grid. The U.S. Environmental Protection Agency's ("EPA") greenhouse gas emissions standards for fossil-fuel generating units (the "Rule") are at issue in this case. To aid the Court's understanding of the technical matters at issue and the reliability impacts of the Rule, this brief clarifies how and why electricity grids are designed and operated as they are; how major trends, including the energy transition, are impacting grid operation; and how such trends are changing approaches to ensuring grid reliability.

[1] *Amici's* credentials are summarized in the Addendum to this brief.

SUMMARY OF ARGUMENT

Petitioners argue that EPA's adoption of the Rule will jeopardize the reliability of the electric power system by prematurely pushing coal-powered generation offline and hindering the construction of new baseload gas plants. In reality, the Rule does no such thing. Independently of the Rule, the grid is already shifting away from coal power toward cheaper and more efficient portfolios of resources, including renewable generation and energy storage, supplemented by flexible natural gas-fired generating capacity. Because these technologies allow for more rapid response to grid needs than fossil-fuel baseload generation, they can actually promote *better* grid reliability than existing coal plants. Moreover, in response to comments, EPA added additional reliability safety measures to provide exceptions to the Rule in cases of particular need.

Regardless of the Rule, the grid is already shifting away from coal power, and grid operators and regulators are already successfully deploying a suite of tools to ensure grid reliability as this transition occurs. Petitioners ignore the availability of resources like energy storage and peaking gas power plants to support a transition away from coal toward variable renewable generation. Grid operators and utilities have a variety of tools and strategies to maintain reliability amidst changing circumstances, and no evidence in the record supports the conclusion that

the Rule will push grid operators beyond their ability to adapt to such changes and sustain reliable service.

Wind, solar, and battery storage are increasingly the most cost-effective new resources, and aging baseload coal plants are ill-equipped to provide the flexibility and fast response needed in a modern grid. Maintaining grid reliability in the face of challenges like extreme weather, aging electrical infrastructure, and growing demand requires addressing the energy transition head-on through evolutions in generation and storage, rather than doubling down on inflexible coal generation. Many grid operators around the country have risen to the occasion, having already transitioned to a reliable grid with significant shares of renewable generation.

Nothing in the Rule will prevent other grid operators from using their ordinary methods to ensure the reliable delivery of electricity. Instead, a modern grid has the potential to alleviate, rather than exacerbate, reliability issues.

Additionally, EPA assessed the effect of the regulation on grid reliability during the rulemaking process and incorporated extra reliability safeguards based upon feedback from grid operators and energy regulators. In sum, EPA has developed a Rule that acts in concert with the ways the grid is already changing and that is wholly consistent with the operation of a reliable, resilient grid.

ARGUMENT

I. The Physical Constraints and Resource Mix of the Grid Shape the Strategies Required to Ensure Reliability of Service.

The electricity grid is an interconnected system in which supply must be balanced with demand in real-time, all of the time, in order to ensure uninterrupted service. Grid operators secure the reliability of this system using a multifaceted set of control systems and back-up capabilities that is constantly evolving alongside the grid itself.

A. Grid operators apply advanced planning and real-time load-balancing to maintain electrical grid reliability.

Grid operators and utilities ensure reliable electricity supply through planning and operational decisions on multiple scales—yearly, seasonally, monthly, weekly, daily, hourly, and in even shorter intervals—as grid operators respond to variable supply, demand, and operational constraints by managing shifts among generators.

Some background on how the electric system works is helpful to understand how grid operators ensure reliability. Every electric generator in the continental United States is linked to other generators and consumers through transmission and distribution lines as part of one of three large regional grids (called "interconnections"). *See generally* Federal Energy Regulatory Commission

("FERC"), *Reliability Explainer*, https://bit.ly/3NjLTUq (Aug. 16, 2023). Each of these electrical interconnections consists of several components essential to ensuring reliable and cost-effective power for consumers: generation, transmission, distribution, and grid operation. **First**, a diverse set of generators converts primary energy (such as coal, natural gas, nuclear, sunlight, or wind) into electricity. Energy storage, including pumped hydroelectric storage and battery energy storage, can absorb or discharge power to complement these generation sources. **Second**, within each grid, a network of high-voltage transmission lines allows power to flow from where it is produced to where it is needed, sometimes over hundreds or even thousands of miles. **Third,** local substations receive electricity from high-voltage transmission lines and lower the voltage for delivery to consumers via local distribution networks. **Fourth**, in any particular electrical area, a single operator (called a "balancing authority") must send signals to schedule and dispatch generators' output so that supply meets demand at all times, even as demand changes in real time.

Interconnection allows grid operators to call upon generators and energy storage facilities to provide power and offers multiple routes for power to travel if a power plant or transmission line goes offline in one area and as demand fluctuates. The fundamental purpose of interconnection is to allow grid operators to continuously balance electricity supply and demand over vast regions, and to

take advantage of different power supply sources (with different costs), thus ensuring all consumers access to reliable and affordable power. This feat is accomplished through orchestrated second-by-second shifts among different generators, which the grids' physical structure is designed to facilitate.

To minimize the overall cost of meeting electricity demand, grid operators dispatch the resources with the lowest variable costs before those that cost more to run, accounting for the physical limits of generators and transmission lines. *See* FERC, *An Introductory Guide to Electricity Markets Regulated by the Federal Energy Regulatory Commission*, https://bit.ly/3Ylxsp4 (Apr. 25, 2024). Renewable energy generators are typically dispatched first because they do not have to purchase fuel, and therefore have lower variable costs than fossil-fuel-fired generators. *See* U.S. ENERGY INFORMATION ADMINISTRATION ("EIA"), ANNUAL ENERGY OUTLOOK 5 (2023), https://bit.ly/3NmgEb9.

Keeping the grid in balance and ensuring it can meet consumers' electricity demand in real time—ensuring grid reliability, in other words—is an essential task of grid operators with oversight from regulators. *See* NATIONAL RENEWABLE ENERGY LABORATORY ("NREL"), EXPLAINED: FUNDAMENTALS OF POWER GRID RELIABILITY AND CLEAN ELECTRICITY 3-5 (2024), https://bit.ly/4f4yV8Z. Every time someone seeks to use electricity, delivering that electricity reliably and instantaneously requires three primary elements: 1) adequate electricity generation,

2) consistent and resilient delivery of that electricity, and 3) effective load balancing.

Planning to ensure the adequacy of resources on the system underpins the ability of the system to meet reliability standards. Planning is critical to ensure there is always adequate generation to meet expected regional demand, plus additional capacity in case generators go offline for maintenance or equipment failures, or extreme heat or cold results in significantly higher demand than expected. Throughout the country, North American Electric Reliability Corporation ("NERC")-certified Balancing Authorities conduct reliability assessment planning and Reliability Coordinators oversee the planning process, all under FERC-approved mandatory Reliability Standards. CONG. RSCH. SERV., MAINTAINING ELECTRIC RELIABILITY WITH WIND AND SOLAR SOURCES 19-22 (2022), https://bit.ly/4eRXcim.

In energy systems that have been restructured, Regional Transmission Organizations ("RTOs") or Independent System Operators ("ISOs") are charged with ensuring reliability, particularly amidst retirements of older generators and the entry of new resources. In regions of the country without an RTO/ISO, an electric utility typically serves as the balancing authority for a particular geographic area of the grid and undertakes long-term planning of generation, storage, transmission

and demand-side management programs to ensure reliability. Nat'l Governors Ass'n, *Electricity Markets–101*, https://bit.ly/3zVN610 (last visited Oct. 17, 2024).

Even with adequate power and a well-maintained system of lines, the grid can fail if electric generation and electricity demand are out of balance at any given moment. Historically, balancing load required second-by-second matching of electricity withdrawals to electricity generation through scheduling and fine-tuning the output of power plants. But today's grid operators have additional tools to balance load that were not widely available until recently. Energy storage systems, for example, can add power to the grid when needed and pull excess power from the grid to recharge the storage system, and they can do so on very short notice. This kind of flexible resource presents a stark contrast with "baseload" resources like coal, which have long ramp times and cannot respond quickly to changes in load. *See* EIA, *Electricity Explained: Electricity Generation, Capacity, and Sales in the United States*, https://bit.ly/3Yko3Os (July 16, 2024).

B. Coal generation is in longstanding decline because it is not competitive with natural gas and renewable generation.

Coal-fired generation has been in decline for over a decade, both in absolute amounts and in the share of total power it provides. Coal produced 45 percent of U.S. electricity in 2010, declining to just 16 percent in 2023. EIA, Electricity Data Browser, https://bit.ly/4h6cpOD (last visited Oct. 17, 2024) (showing coal

produced 1,847 million megawatt-hours ("MWh") out of 4,125 million MWh total in 2010, and 675 million MWh out of 4,178 million MWh in 2023). In the U.S., coal generation at many power plants simply cannot compete with the efficiency and flexibility of gas generation technologies coupled with low gas prices, or with the low operational costs of renewable generation.

A reasonable expected operating life of coal-fired units is 40 years, but the average age of the currently operating coal fleet is 47.2 years. BRATTLE GROUP, A REVIEW OF COAL-FIRED ELECTRICITY GENERATION IN THE U.S. 18 (2023), https://bit.ly/3YkOpzR. Aging coal plants become more expensive to maintain and operate, and can become increasingly unable to provide many needed reliability services. *Id.* at 19 (on operating costs of aging coal plants). As a result, it is less expensive to build new renewable generation than to continue to maintain and operate coal-generating units that are already beyond their expected operating lives.

Due to the systems of economic dispatch described above, the retirement of coal generation and the entry of new natural gas and renewable generation are interrelated. Significant growth of renewable generation capacity and expansion of natural gas have contributed to decreasing output at coal-fired power plants as a natural outcome of market forces in combination with federal financial incentives, state policies, and purchasing preferences of many large electricity customers.

Renewable generation in the U.S. surpassed coal generation in 2022, and the gap increased in 2023. EIA, *Renewable Generation Surpassed Coal and Nuclear in the U.S. Electric Power Sector in 2022,* EIA (Mar. 27, 2023), https://bit.ly/3Ykiy2n; *see* EIA, ELECTRIC POWER MONTHLY: FEBRUARY 2024 Table Es1.a (2024)), https://bit.ly/3U5PUQ4.

While facilitated by economic dispatch principles, the decline in coal is driven primarily by competitive pressure from natural gas, renewables, and increasingly energy storage. Combined cycle gas generation is now significantly more efficient and more flexible than most coal-fired steam generation units. EIA, *Most Combined-Cycle Power Plants Employ Two Combustion Turbines with One Steam Turbine* (Apr. 25, 2022), https://bit.ly/3U4g8SQ. Renewable generation, meanwhile, has near-zero operating costs, and with rapidly evolving technology alongside policy incentives, the overall costs of renewable generation are falling rapidly. LAZARD, LEVELIZED COST OF ENERGY 16 (2024), https://bit.ly/4h0XPYO. In many regions, battery storage capacity is also growing rapidly, with 15 gigawatts ("GW") of batteries expected to be installed in 2024. EIA, *U.S. Power Grid Added 20.2 GW of Generating Capacity in the First Half of 2024* (Aug.19, 2024), https://bit.ly/4dMmMEz.

Coal's decline shows no signs of slowing and is projected to continue. SUSAN TIERNEY, ANALYSIS GROUP, U.S. COAL-FIRED POWER GENERATION:

MARKET FUNDAMENTALS AS OF 2023 AND TRANSITIONS AHEAD 38-40 (2023) https://bit.ly/4f3rPSa. This reduction is expected to be frontloaded, with a heavy decline before 2030 and most of the aging and less efficient coal infrastructure likely retiring before 2040. *Id.* These retirements are being driven by market forces and state policies, not by the Rule. The adoption of renewable generation and energy storage, meanwhile, is increasing at near exponential rates. *See* Joel Jaeger, *Explaining the Exponential Growth of Renewable Energy*, WORLD RSCH. INST. (Sept. 20, 2021), https://bit.ly/4h0mFIe.

C. Grid operators deploy a variety of techniques to ensure reliability, allowing them to operate grids with increasing renewables penetration, including multiple coal-free systems.

To respond to these changing grid characteristics—declining coal generation, rapid renewables growth, and a rise in extreme weather events—grid operators employ a robust and evolving set of tools to ensure operational reliability on the grid. BRATTLE GROUP, BULK SYSTEM RELIABILITY FOR TOMORROW'S GRID 87 (2023), https://bit.ly/4eYHNN3. Tools that grid operators can deploy to support this transition include: greater overall generation capacity; a geographic diversity of renewables siting; diversity of types of generation; robust interconnection and improved transmission infrastructure; demand response and load flexibility tools that can better align demand with the availability of renewable energy; the deployment of energy storage; better forecasting of weather and its impacts on

electricity use and supply; and improved tools to provide situational awareness and visibility into operating conditions around the grid. *See id.* Each of these tools helps to accommodate the variability of renewable sources and provides additional benefits to grid reliability.

A portfolio of diverse generation sources, including renewables, can replace aging infrastructure, meet growing demand, and ensure resource adequacy because in aggregate these different types of generating equipment offer reliability services that can match and even exceed what an aging baseload power plant provides. PAUL HIBBARD ET AL., ANALYSIS GROUP, ELECTRICITY MARKETS, RELIABILITY, AND THE EVOLVING U.S. POWER SYSTEM 49 (2017), https://bit.ly/3Y30RDa. This is true for three main reasons.

First, replacing aging fossil fuel plants with a portfolio of modern, flexible resources enhances reliability by reducing the system's reliance on large generating units with limited ability to change levels of output, in favor of smaller, more nimble and flexible generators and storage that are better able to follow changes in load and supply. The notion that baseload power from coal-fired plants is essential for reliability is outdated. EIA, *Electric Power Monthly,* https://bit.ly/3zYFzP4 (last visited Oct. 17, 2024) (showing the coal fleet average capacity factor, *i.e.* utilization level, declining from over 60 percent in 2014 to 42 percent in 2023). 'Baseload' refers to the lowest level of electricity demand

experienced as demand rises and falls over time. It is not necessary to operate generators continuously to meet this level of demand. Instead, system operators maintain a cost-effective portfolio of generation and storage resources that can meet demand at all times and all conditions, and that portfolio has increasingly eschewed coal-fired power.

Meanwhile, coal-fired power plants are experiencing increasing levels of unplanned outages, including in the face of extreme weather, meaning they do not necessarily ensure reliability advantages over renewables. In 2022, conventional generation "experienced its highest level of unavailability (8.5%) overall since NERC began gathering [Generating Availability Data Systems] data in 2013." NERC, 2023 STATE OF RELIABILITY OVERVIEW 7 (2023), https://bit.ly/3Y4Bscd.

Second, load growth and new resource additions are driving the development of new transmission capacity, which itself enhances resilience. Regulators and grid operators have committed to speeding the interconnection of new renewable generation.[2] New and upgraded transmission infrastructure will improve reliability by modernizing equipment and building in redundancy that will lessen risks from network outages and wildfire danger. These upgrades will also

[2] FERC recently issued a rule to streamline long-term transmission planning and cost-allocation. Building for the Future Through Electric Regional Transmission Planning and Cost Allocation, 89 Fed. Reg. 49,280 (June 11, 2024). The Department of Energy promulgated a new rule to streamline permitting of transmission. 89 Fed. Reg. 35,312 (May 1, 2024) .

allow for greater throughput capability and allow regions to aid one another during challenging grid conditions. *See generally* DEP'T OF ENERGY, NATIONAL TRANSMISSION PLANNING STUDY (2024), https://bit.ly/3NoAkva.

Third, the geographic and source diversity of new renewable generation will provide additional resilience. A more geographically diverse array of generation resources increases systemwide resiliency to weather variation, extreme weather events, and variations in the timing and shape of consumers' demand. Resource diversification also reduces risks associated with fuel supply constraints and price shocks. NREL, RENEWABLE ENERGY TO SUPPORT ENERGY SECURITY 3 (2019), https://bit.ly/3Nlcqk6.

Grid operators and utilities have demonstrated their resilience to changing circumstances, whether driven by changes in demand, emergence of new technologies, new policy and regulation, or evolving market conditions. RTO-*Amici* describe how during the initial Mercury and Air Toxics (MATS) rule, PJM Interconnection "efficiently replaced 20,000 MW of coal generation with new, cleaner, natural gas generation that took advantage of the shale gas revolution that was occurring simultaneously." RTO-*Amicus* Br. 23 (Sept. 13, 2024), ECF No. 2074675. RTO-*Amicus* Southwest Power Pool ("SPP") maintained system reliability as variable renewable energy grew from 4 percent in 2010 to over 36 percent in 2023, with wind occasionally supplying over 90 percent of electricity

demand. SPP, ANNUAL REPORT 1 (2010), https://bit.ly/3No5qmt; Fast Facts, SPP, https://bit.ly/3Y6ZnrB; SPP, *SPP Sets Regional Records for Renewable Energy Production* (Mar. 29, 2022), https://bit.ly/484HGgK.

Meanwhile, multiple grids around the country operate reliably with no or negligible amounts of coal, and with an increasing percentage of renewables and storage. The New York Independent System Operator has operated without coal since 2020. Will Wade, *New York's Last Coal-Fired Power Plant to Retire Tuesday*, BLOOMBERG (Mar. 30, 2020), https://bit.ly/403CLLi. The six states within the Independent System Operator of New England have operated with zero to 2 percent of generation from coal since 2019, with plans to retire the last coal plant by 2028. Minho Kim, *The Last Coal-Fired Power Plants in New England Are to Close*, N.Y. TIMES (Mar. 28, 2024), https://bit.ly/3Y1LsDc. The California Independent System Operator, which is also almost entirely coal-free, meanwhile, has increased its battery storage capacity from near zero in 2020 to over 11 GW in mid-2024, four times the capacity of its largest generating plant, enabling the state to run on 100% renewable energy for parts of 70 out of 90 days this spring. Amber Motley, *New Renewables Records,* CAL. INDEP. SYS. OPERATOR ENERGY MATTERS (June 6, 2024), https://bit.ly/3ZVKUkO; CAL. INDEP. SYS. OPERATOR, 2023 SPECIAL REPORT ON BATTERY STORAGE 4 (2024), https://bit.ly/401fzNG.

In regulated states without RTOs, many utilities are planning to meet future needs by retiring coal and building new renewable generation paired with battery storage. For example, the largest retail utility in the U.S., Florida Power and Light, plans to retire all of its coal (715 megawatts) by 2029, build no new natural gas plants, and meet demand growth with 21 GW of solar and over 4 GW of energy storage by the end of 2033. FPL, TEN YEAR POWER PLANT SITE PLAN 5 (2024), https://bit.ly/3Y5FqkY. Xcel Energy plans to operate coal-free in Colorado after 2030, largely replacing these resources with wind, solar, and energy storage. Xcel Energy, *Colorado Clean Energy Plan*, https://bit.ly/3YmCul7 (last visited Oct. 17, 2024). These grid operators and utilities are providing roadmaps for others to follow on how to effectively operate electric grids based on renewables and storage, while phasing out coal.

Detailed electricity system modeling has found that the grid can continue a transition away from coal, significantly increase shares of variable renewable energy sources, and meet the grid's resource adequacy and reliability requirements, even under constrained circumstances. *See, e.g.,* DEREK STENCLIK ET AL., GRID LAB, RELIABLY REACHING CALIFORNIA'S CLEAN ELECTRICITY TARGETS 6-10 (2022), https://bit.ly/3Y875BO (showing the western U.S. grid can reliably meet demand under periods of stress, with full transition away from coal and accelerated clean energy deployment); DEP'T OF ENERGY, NATIONAL TRANSMISSION PLANNING

STUDY: EXECUTIVE SUMMARY 3 (2024), https://bit.ly/3NoAkva (same, nationwide, including robust production cost and power flow modeling); QINGYU XU ET AL., PRINCETON ZERO LAB, CLEANER, FASTER, CHEAPER: IMPACTS OF THE INFLATION REDUCTION ACT AND A BLUEPRINT FOR RAPID DECARBONIZATION IN THE PJM INTERCONNECTION 8 (2022), https://bit.ly/4eIUk7z (same in PJM region, under IRA plus Cap-and-Trade scenario). The changes experienced by the electricity sector over the past several decades are expected to extend going forward. These studies demonstrate pathways for grid operators and utilities to respond to these changes while maintaining a reliable electricity system.

II. The Rule Will Not Jeopardize Grid Reliability.

The Rule will not, as Petitioners claim, "jeopardize the reliability of the Nation's electricity system." *See* Pet'r Brief 90. Petitioners' errors are manifold: They misattribute to the Rule a causal role in forcing coal plants to retire, when instead the Rule is expected to have only an incremental impact amid longstanding trends of coal power plant closures and growth in more resilient energy sources, like solar and energy storage. Petitioners also erroneously assert that new resources will not be able to fill the gap left by the closure of coal plants, while in fact the Rule provides sufficient time for the grid to adjust to a new generation mix, as well as Compliance Flexibilities in cases of particular grid needs. Finally, Petitioners

mischaracterize EPA's consideration of reliability concerns throughout the rulemaking process.

A. The Rule operates in the context of a longstanding trend away from coal and toward renewable generation that will improve, not jeopardize, reliability.

While petitioners argue that the Rule will "jeopardize the reliability" of the electric system by "forc[ing] the retirement of dispatchable sources of generation," this claim is not based in fact. *See* Pet'r Br. 90. First, as described in Respondents' Brief at 102-104, the Rule will not force plant retirements—generators and states have a variety of choices about how to comply with the Rule. More saliently, there is strong evidence that the current independent trend of accelerating coal plant closures and parallel buildout of renewable generation and infrastructure will *improve*, not harm, reliability and resiliency.

As described in Part I, *supra*, coal-fired steam generating units have slow ramp rates, high minimum loads, long startup times, and are inflexible from an operational point of view, which makes them ill-suited to providing the flexibility needed to manage the modern grid. Meanwhile, modern grid management tools like energy storage can adjust rapidly to highly variable load and changing generation output. The Rule also allows for existing and new gas-fired generators to contribute to capacity and flexibility needs.

While Petitioners argue, Pet'r Br. 91, that the Rule's restrictions on new gas-fired power plants will harm reliability, this is not the case. New gas generators that will operate at low-load (less than 20 percent annual capacity factor) and intermediate-load (20-40 percent annual capacity factor) can satisfy the Rule with standard technology without any additional controls to reduce carbon pollution.[3] Rule at 39,917, JA0120. Low and intermediate-load gas plants can be deployed to fill in load gaps for variable renewable resources, provide operational reliability services, and provide their full capacity in the hours when the grid needs it most. JA0106-07. Existing gas generators are also unaffected by the Rule and can provide reliability value to the grid. JA0044-45.

Petitioners spuriously argue that EPA selectively focused on only one element of reliability—resource adequacy—at the expense of "operational or other aspects" of grid reliability. Pet'r Br. 99; *see also* Petitioner Intervenors' Brief 35, ECF No. 2073620 (Sept. 6, 2024). Yet Petitioners offer no reason why these other aspects of reliability would fare worse under the Rule. In fact, a modern grid based upon renewables and storage is actually *better* equipped than coal generation to support operational reliability, including multiple attributes in Petitioner-

[3] The Rule does require baseload gas plants that operate above a capacity factor of 40 percent to meet a standard based on deployment of carbon capture and sequestration, but, as discussed in Part I.B above, renewables are increasingly available as a lower cost alternative to fossil-fuel baseload.

Intervenors' list of elements of concern. *See* Pet'r-Intervenors' Br. 35 (arguing that EPA failed to consider "fuel assurance, black start capacity, dispatchability, and flexibility.").[4] In particular, renewable generation paired with storage performs better than coal generation at dispatchability and flexibility. Michael Milligan, *Sources of Grid Reliability Services*, 9 ELEC. J. 1, 5-6 & tbl.1 (2018), https://bit.ly/3Y9kzx0. Dispatchability refers to the ability of a unit to respond to grid operators' commands. Flexibility refers to the ability to change output levels quickly in response to grid needs. Energy storage is both more easily dispatchable and more flexible than coal plants. Existing gas-fired power plants, as well as new gas generators that meet the requirements of the Rule are also more flexible and respond more rapidly to changing grid conditions than coal-fired steam generators. *See* NAT'L ASS'N OF REGUL. UTIL. COMM'RS, RECENT CHANGES TO U.S. COAL PLANT OPERATIONS AND CURRENT COMPENSATION PRACTICES 22 (2020), https://bit.ly/48b3LdQ (explaining that coal plants' high fixed costs, long start-up

---

[4] Fuel assurance is not a NERC reliability requirement, and in 2018 FERC ruled against a Department of Energy proposal that would provide compensation to plants with assured onsite fuel storage, suggesting this is not a reliability priority. *Grid Resilience in Reg'l Transmission Organizations & Indep. Sys. Operators*, 162 FERC ¶ 61,012 at 11 (Jan. 8, 2018). Black start is the process of restoring the grid from a catastrophic failure, and black start units are typically gas combustion turbines. Existing, as well as new low-and-intermediate-load, gas plants, are unaffected by this Rule. In addition, energy storage can serve as a black start resource.

times, slow ramping and high minimum stable output levels make flexible coal operation uneconomic relative to other options).

In sum, the longstanding shift away from coal generation toward renewables and storage will not harm reliability, but will instead catalyze changes to the grid that will make it more nimble, resilient, and flexible.

B. The Rule provides sufficient time to plan, procure, build, and interconnect resources necessary to maintain a reliable grid.

Petitioners incorrectly argue that the Rule will cause "impending grid reliability issues" because "limited new resources cannot possibly fill the gap that will be left via early retirement of coal-fired plants." Pet'r Br. 90, 93. In fact, the timelines in the Rule are more than adequate to plan and procure new resources to replace coal plants that owners choose to retire. If plant owners plan to comply with the Rule by retiring units, the Rule allows them to continue operating these plants until 2032.[5] Rule at 39,801, JA0004. When power plant owners choose to

---

[5] RTO-*Amici* argue that the Rule will have a "chilling impact" on existing generation, and that units may choose to retire even before 2032 as required by the Rule, threatening reliability. RTO-*Amicus* Br. 20. If these units are required for reliability in the near term, however, markets will send the correct price signals to keep these units online while replacement resources are constructed. For example, PJM's recent capacity auction had prices 10x higher than its previous auction, showing that markets are sending the correct pricing signals for new entry as well as units to stay online. PJM, 2025/2026 BASE RESIDUAL AUCTION REPORT 4 Table 2 (2024), https://bit.ly/3Y9sNW3. In regulated markets, load growth is delaying retirements of coal plants so utilities have more time to construct replacement

retire their units, they must indicate their intention to do so to grid operators, who then perform reliability analyses to determine how to ensure reliability before the unit is allowed to retire. *See, e.g.*, PJM, *Manual 14D: Generator Operational Requirements* § 9.1, https://bit.ly/3U4RHVB (requiring generators to notify PJM at least two calendar quarters before any proposed requirement and setting forth a detailed reliability review process).

Seven years is ample time for utilities and grid operators to plan and procure additional resources to replace the energy, capacity and other services provided by the retiring units. Indeed, there are already new generation resources ready to come online far exceeding the amount of projected coal retirements under the Rule. *Compare* Resource Adequacy Analysis Technical Support Document 9, EPA-HQ-OAR-2023-0072-8916, JA5542 (projecting 21 incremental GW of coal retirements from the Rule in 2035, beyond the 83 GW baseline) *with* JOSEPH RAND ET AL., LAWRENCE BERKELEY NAT'L LAB'Y, QUEUED UP: 2024 EDITION 21 (2024), https://bit.ly/3Ns5Vfz (showing 311 GW of resources with executed interconnection agreements ready to come online in the next 2-3 years, with an additional 300 GW in the final facilities study stage, and a total of 2,600 GW of resources seeking to connect to the grid). Plant operators can alternatively choose

---

resources. *See, e.g.*, Georgia Power, *Georgia PSC Finalizes and Approves Georgia Power's 2023 IRP Update* (Apr. 16, 2024), https://bit.ly/489eVQf.

to comply with the Rule by converting coal units to gas-fired operation.[6] This compliance pathway leverages well proven technology, with over 100 power plants in the U.S. converting from coal to gas during the years 2011-2019. EIA, *More Than 100 Coal-Fired Plants Have Been Replaced or Converted to Natural Gas Since 2011* (Aug. 5, 2020), https://bit.ly/3U3sISj.

In sum, the Rule does not require plant retirements or change the underlying dynamics already driving the industry's turn away from increasingly uneconomic coal generation. The Rule offers flexibility to electric generating units ("EGUs") to choose from several strategies to meet the Rule's requirements. System operators and utilities also have significant flexibility to use a portfolio of modern generation, storage and demand management resources to maintain reliable and affordable grid operations. To the extent that the choices facing coal generating units are constrained, this constraint reflects the increasingly and fundamentally uneconomic nature of coal generation in a changing energy landscape, not an overly stringent Rule.

---

[6] Petitioners argue that these conversions are infeasible, due to lack of pipelines, and insufficient time for conversion. While there may be a small number of units that are far from existing gas pipelines, many other units are close to existing pipelines, and gas pipeline infrastructure is constantly expanding, with over 23,500 miles of new gas transmission pipeline constructed in the past 20 years. CONG. RSCH. SERV., INTERSTATE NATURAL GAS PIPELINE SITING: FERC POLICY AND ISSUES FOR CONGRESS 3 (2021), https://bit.ly/4eD3bI2.

C. The Rule's Compliance Flexibilities provide additional backstops to maintain existing resources in cases of particular need.

To the extent there are unique circumstances that cause particular grid stress, the Rule includes multiple compliance flexibilities to protect system reliability. Rule at 39,978-79, JA0181-82. The Remaining Useful Life and Other Factors ("RULOF") framework is a mechanism states can invoke to "provide for less stringent standards of performance for affected EGUs under certain circumstances." *Id.* The Rule also permits emission trading, averaging, and unit-specific mass-based compliance in certain circumstances. *Id.* Finally, the Rule includes two mechanisms that provide additional flexibilities where grid reliability is implicated: the short-term reliability mechanism[7] and the reliability assurance mechanism. Rule at 40,012-14, JA0215-17.

As a final safeguard, the Rule does not limit a generator's ability to seek an emergency waiver authorization from the Department of Energy under Federal Power Act Section 202(c), 16 U.S.C. § 824a(c). The Department of Energy can waive compliance with environmental standards when necessary to ensure

[7] RTO-*Amici* argue that the short-term reliability mechanism should be applicable at an Energy Emergency Alert level 1, "when operators are still able to access additional generation to increase the supply of electricity." RTO-*Amicus* Br. 27. EPA considered this argument but concluded that including level 1 "would carry a greater risk of increasing overall greenhouse gas emissions without making a meaningful contribution to supporting reliability." Rule at 39,914, JA0117.

reliability, given sudden changes in electricity demand. *See* U.S. Dep't of Energy, *DOE's Use of Federal Power Act Emergency Authority*, https://bit.ly/3YsWfHQ (last visited Oct. 17, 2022).

D. EPA consulted grid reliability experts and grid operators and applied standard-practice energy system modeling, resulting in a well-considered Rule that will not jeopardize reliability.

It is not surprising that the Rule does not jeopardize reliability. EPA considered reliability as it developed the Rule, consulting extensively with grid reliability experts and working in collaboration with affected Regional Transmission Organizations to address concerns throughout the rulemaking process. In addition, EPA used industry-standard modeling to assess energy system effects, verifying that reliability will not be harmed. EPA robustly considered the potential impacts of its Rule on grid reliability and acted to mitigate risks.

i. EPA consulted grid operators and grid reliability experts and adapted the Rule to address their concerns.

Throughout the rulemaking process, EPA engaged with commenters to arrive at a final rule that ensured grid reliability would not be compromised. EPA followed up with the grid operators that submitted comments on the Rule and met repeatedly with technical staff and Commissioners of FERC, NERC, and the Department of Energy. Rule at 39,803, 40,011, JA0006, JA0214. In response to commenters' concerns over grid reliability and resource adequacy, EPA

specifically requested more granular input on reliability in a supplemental Notice of Proposed Rulemaking. 88 Fed. Reg. 80,682 (Nov. 20, 2023).

In response to stakeholder engagement, EPA modified the Rule's performance standards and added new features, both to improve compliance flexibility and to provide additional emergency reliability measures. Joint-RTO comments proposed adjusting the compliance schedule for existing gas and coal units "based on an examination as to whether the CCS and hydrogen co-firing infrastructure is developing at a sufficient pace." Comments of Joint ISOs/RTOs 3 (Aug. 7, 2023), EPA-HQ-OAR-2023-0072-0673, JA1624. EPA modified the proposed rule to provide two years of additional lead time for carbon capture and storage installation and declined to finalize the 30% hydrogen co-firing BSER for the intermediate subcategory for new combustion turbines. Rule at 40,012, JA0215. EPA also modified the final rule to restructure subcategories for coal-fired steam generators, providing states with more planning latitude and exempting units with retirement planned prior to 2032. *Id*.

In addition to modifying the Rule's standards, EPA designed new compliance flexibilities to ensure the Rule would not compromise grid reliability. Rule at 39,978, JA0181. Following Joint-RTO commenters requesting "specific recognition in the Rule of the availability of allowance trading...to allow for greater flexibility," EPA included emission averaging, trading, and unit-specific mass-

based compliance mechanisms for applicable subcategories, as well as two dedicated reliability mechanisms: the short-term reliability mechanism and the reliability assurance mechanism. Rule at 40,012, 40,014, JA0215, JA0217; Comments of Joint ISOs/RTOs 6, JA1627. In response to comments, the Rule also clarified how states are to employ the RULOF framework,[8] another compliance flexibility. Rule at 39,962, JA0165.

Indeed, a representative of RTO-*Amicus* PJM praised EPA for responding to grid operator comments, noting that EPA "really did listen" and made "some very notable changes in the rules, which we're very grateful for…." EPA Policy Forum to Address Carbon Emissions from Existing Combustion Turbines in the Power Sector, Remarks of Craig Glazer (PJM), Dkt. ID EPA-HQ-OAR-2024-0135, Doc. EPA-HQ-OAR-2024-0135-0126, Att. 3 Transcript 21-22 (May 17, 2024),

[8] RTO-*Amici* acknowledge that the RULOF doctrine "was a helpful and appreciated addition to the final rule," but insist that it still lacks "guidance on what would constitute an acceptable plan invoking RULOF." RTO-*Amicus* Br. 28. This is incorrect. The final rule enumerates the elements upon which states must base their invocation of RULOF ("location, or basic process design; physical impossibility or technical infeasibility of installing necessary control equipment; or other circumstances specific to the facility") and clarifies that states must demonstrate "fundamental differences" between this information for the facility in question and the information EPA relied upon in setting the best system of emission reduction for the category. Rule at 39,836, JA0039.

https://bit.ly/3UdJZZs (describing EPA's response to PJM's comments on this Rule, in a separate docket on potential future rulemaking).

In sum, EPA robustly engaged with energy grid experts, including RTO-*Amici*, during the rulemaking process, and modified the Rule to address many of their concerns.

ii. EPA used industry-standard modeling to assess potential impacts to the grid under a variety of scenarios, finding no significant impacts to reliability.

EPA conducted extensive analyses of the Rule's impact on resource adequacy and reliability using the Integrated Planning Model ("IPM"), an industry standard capacity expansion model. *See* Resource Adequacy Analysis Technical Support Document 5 (April 2024), EPA-HQ-OAR-2023-0072-8916, JA5538. Applying this model, EPA found that "projected impacts to the resource mix are relatively modest, and that strong institutional mechanisms exist to preserve resource adequacy." *Id.* at JA5535. Petitioners argue that this IPM modeling was incomplete and flawed. Pet'r Br. 101; Pet'r-Intervenor Br. 32. However, EPA's modeling is the same approach taken by utilities in their Integrated Resource Plans, and by grid operators when forecasting the generation mix for transmission planning. For example, RTO-*Amicus* Midcontinent Independent System Operator ("MISO") uses a similar model, EGEAS, to forecast capacity in its footprint.

MISO's "Future 2A," which MISO used to develop its most recent transmission portfolio, forecasts a generation mix in 2032 that is congruent with the Rule: coal is mostly retired by 2035, and is replaced with solar, wind, and battery storage. MISO, MISO FUTURES REPORT 2, 72, 105 (2023), https://bit.ly/4h6LBxS.

Petitioners also erroneously assert that EPA failed to consider key aspects of the reliability analysis, including the effects of higher electricity demand and how the Rule might combine with other EPA actions to exacerbate reliability issues. *See* Pet'r Br. 99. In fact, EPA conducted multiple sensitivity analyses, including ones that examined the impact of higher electricity demand and the impact of other EPA rules affecting the power sector, and found that the sector has feasible pathways to comply with the Rule that satisfy reliability constraints. *See* Rule at 40,013, JA0216; IPM Sensitivity Runs Memo 4-5 (April 2024), EPA-HQ-OAR-2023-0072-8917, JA5566-67. With respect to how the Rule would interact with other recent regulations, EPA found that "the 111 EGU Rules, whether alone or combined with other Rules, are unlikely to adversely affect resource adequacy." EPA Resource Adequacy Analysis: Vehicle Rules, Final 111 EGU Rules, ELG, and MATS RTR Technical Memo 3 (April 2024), EPA-HQ-OAR-2023-0072-8915, JA5496.

In formulating the final rule, EPA conducted multiple sensitivity analyses, consulted extensively with stakeholders, issued a supplemental notice of proposed rulemaking seeking additional information about grid reliability, modified standards in response to stakeholder input, introduced new compliance flexibilities aimed at reliability, and introduced additional reliability mechanisms on top of the Federal Power Act's emergency reliability mechanism. Rule at 39,803, 40,014, JA0006, JA0217. The Rule is robust, well-considered, and contains safeguards to support grid reliability.

CONCLUSION

A transformation is well underway in our electric power system. That transformation is defined by a shift away from coal-fired generation and towards a portfolio of renewable generation, storage, and flexible gas-fired generation, and is paired with a suite of tools to enhance grid reliability throughout this transition. EPA's Rule correctly takes this transformation into consideration but will not drive its outcome. Instead, the Rule makes reasonable and justified assumptions about this transformation, resulting in a Rule that will have no material impacts on grid reliability.

CERTIFICATE OF COMPLIANCE

I hereby certify that the foregoing brief complies with the type-volume limitations set forth in D.C. Cir. R. 32(e)(3) and Fed. R. App. P. 29(a)(5) because this brief contains 6473 words, excluding the parts of the brief exempted by Fed. R. App. P. 32(f) and D.C. Cir. R. 32(e)(1). The foregoing brief complies with the typeface requirements of Fed. R. App. P. 32(a)(5) and the type style requirements of Fed. R. App. P. 32(a)(6) because this brief has been prepared in a proportionally spaced typeface using Microsoft Word in 14-point Times New Roman font.

/s/ Denise Grab
DENISE GRAB
November 7, 2024

CERTIFICATE OF SERVICE

I hereby certify that, on this 7th day of November, 2024, I caused the foregoing to be electronically filed with the Clerk of the Court for the United States Court of Appeals for the District of Columbia Circuit using the Court's CM/ECF system, which constitutes service on all parties and parties' counsel who are registered ECF filers.

/s/ Denise Grab
DENISE GRAB
November 7, 2024

ADDENDUM – CREDENTIALS OF GRID EXPERTS

Ric O'Connell is the Executive Director at GridLab and has performed numerous studies on power systems reliability, renewable energy integration, project economics, and transmission planning for over 20 years. He has significant professional experience with modeling future power systems, and has published many widely read reports and analysis on current and future power systems. Prior to founding GridLab, he was an executive and engineer at Black & Veatch for 12 years, where he performed engineering design and diligence on dozens of utility scale solar projects, and assisted several utilities with planning and procuring new resources. He has been on the board of the Energy Systems Integration Group since 2018. He has a Masters in Science from the University of Colorado, Boulder, and a Bachelor of Science in Electrical Engineering from Duke University.

Brendan Pierpont, the Director of Electricity Modeling at Energy Innovation, LLC, is an expert in electricity market design, electricity resource adequacy and reliability, coal power plant economics and the economics of power plant pollution control regulation. He has over 15 years of experience modeling the economics of electricity sector resources, evaluating utility resource planning analyses, and analyzing electricity sector data and trends. He has authored research reports on electricity sector policy and market issues and has provided research and

analysis to policymakers, market participants, and public interest stakeholders. He is familiar with utility integrated resource planning processes and recent plans filed by utilities around the country. He holds a Master's degree in Management Science and Engineering from Stanford University, with a focus on energy system modeling and analysis.

Benjamin F. Hobbs is the Theodore M. and Kay W. Schad Professor in Environmental Management in the Department of Environmental Health and Engineering at Johns Hopkins University ("JHU"). He has a joint appointment in the Department of Applied Mathematics and Statistics, and is Global Director of the Electric Power Innovation for a Carbon-free Society, a multi-country research center supported by the National Science Foundation. His research focuses on electric power and energy market planning, risk analysis, and environmental and energy systems analysis and economics. He is Chair of the California Independent System Operator Market Surveillance Committee and a Fellow of the Institute of Electrical and Electronics Engineers and the Institute of Operations Research and Management Science. He was also a consultant to the PJM Independent System Operator and developed the methodology it uses to create its capacity market demand curve as part of its original Reliability Pricing Model. From 1995 to 2002, he was consultant to the Federal Energy Regulatory Commission's Office of the

Economic Advisor. He holds a Ph.D. in Environmental Systems Engineering from Cornell University.

Jesse D. Jenkins is an assistant professor and macro-scale energy systems engineer at Princeton University with a joint appointment in the Department of Mechanical and Aerospace Engineering and the Andlinger Center for Energy and Environment. He is also an affiliated faculty with the Center for Policy Research in Energy and Environment at the School of Public and International Affairs and an associated faculty at the High Meadows Environmental Institute.

Jesse completed a PhD in Engineering Systems ('18) and SM in Technology and Policy ('14) at the Massachusetts Institute of Technology and a BS in Computer and Information Science ('06) at the University of Oregon. He worked previously as a postdoctoral fellow at the Harvard Kennedy School, researcher fellow at Argonne National Laboratory, and spent six years as an energy and climate policy analyst prior to embarking on his academic career.

At Princeton, Jesse leads the ZERO Lab (Zero-carbon Energy systems Research and Optimization Laboratory), which focuses on improving and applying optimization-based energy systems models to evaluate and optimize low-carbon energy technologies, guide investment and research in innovative energy

technologies, and generate insights to improve energy and climate policy and planning decisions.

Jesse recently served on the National Academies of Science Engineering and Medicine expert committee on Accelerating Decarbonization of the U.S. Energy System, was a principal investigator and lead author of Princeton's landmark Net-Zero America study, and leads the REPEAT Project (repeatproject.org), which provides regular, timely, and independent environmental and economic evaluation of federal energy and climate policies as they are proposed and enacted. He has delivered invited testimony to multiple Congressional committees and his research is frequently featured in major media outlets. He regularly provides technical analysis and policy advice for non-profit organizations, policy makers, investors, and early-stage technology ventures working to accelerate the deployment of clean energy. He is currently an advisor to Rondo Energy, Eavor Technologies, MUUS Climate Partners, Energy Impact Partners, and Clean Air Task Force and is a partner with DeSolve, LLC, which provides decision support, analytics, and policy advisory services.

Brendan Kirby is a private consultant with clients including the Hawaii Public Utilities Commission, Grid Lab, National Renewable Energy Laboratory, Energy Systems Integration Group, Electric Power Research Institute, American

Wind Energy Association, Oak Ridge National Laboratory, and others. He has forty-nine years of electric grid experience, and has published over 180 papers, articles, book chapters, and reports on power system reliability and integrating renewable energy generation into the power grid. He was a member of the North American Electric Reliability Corporation's Essential Reliability Services Task Force, and previously served on its Standards Committee. He retired from the Oak Ridge National Laboratory's Power Systems Research Program. He is a Licensed Professional Engineer with an M.S. degree in Electrical Engineering (Power Option) from Carnegie Mellon University and a B.S. in Electrical Engineering from Lehigh University.

Kenneth J. Lutz is an Affiliated Professor in the Department of Electrical and Computer Engineering at University of Delaware, where he does research and teaches specially designed courses on the modernization of the electric grid. He has decades of experience in the regulation of utilities. He founded AMR Strategies, LLC, to help utilities modernize their grids. Previously, he served as an IEEE/American Association for the Advancement of Science Congressional Fellow for United States Senator Ron Wyden, where he played a key role in drafting federal legislation for renewable energy and energy efficiency. He has a Ph.D. in electrical engineering from the Johns Hopkins University and a B.E.E. from the University of Delaware.

Michael Milligan retired in 2017 from the National Renewable Energy Laboratory, as Principal Researcher in the Power System Research Center. In 2017 he launched Milligan Grid Solutions, Inc, which focuses on power system reliability, economics, and rational strategies to integrate wind and solar power into the bulk power system. As a consultant, he has been hired by the North American Reliability Corp. (NERC) to give an all-day workshop on reliability to NERC staff; has consulted for the Electric Power Research Institute (EPRI), producing papers on reliability; and as a consultant to GridLab, has actively participated in the MISO Resource Adequacy Subcommittee and many other bulk system issues. Michael has delivered in-person workshops on reliability at FERC, SPP, PJM, and various state Public Utility commissions. Many of these workshops and presentations have focused on recent research showing how wind, solar, and batteries can provide grid reliability services that have traditionally been provided by large thermal units, such as coal resources.

For 25 years at NREL, Michael worked on a wide variety of issues related to wind and solar integration into the bulk power system. Much of his research focused on reliability. He was recruited by NERC to serve on the Integrating Variable Generation Resources Task Force in 2008, where he led working groups that published NERC reports on long-term reliability and capacity accreditation, and probabilistic methods for analyzing power system analysis. Michael was a

charter member of the IEEE Wind Capacity Value Task Force, which produced IEEE Transactions papers on reliability and capacity accreditation.

Michael is an internationally-recognized expert in reliability, and as an active member of the International Energy Agency Task 25 (how to design and operate power systems with large amounts of wind power) at NREL, he led the development of several papers on resource adequacy and reliability, and presented at international conferences. His work at NREL contributed significantly to the formation of the Western Energy Imbalance Market. He led various task forces for key Department of Energy reports, such as the Wind Vision, Hydro Power Vision, and the Electricity Futures Study, published by NREL.

Michael has authored or co-authored more than 230 technical papers, book chapters, and journal articles. He received NREL's highest research award, the H.M. Hubbard award for outstanding research contributions and leadership in science and technology for two decades, in 2010. He also received a Lifetime Achievement Award from the Energy Systems Integration Group (ESIG) in 2018. At NREL, he received several other annual research awards.

Michael O'Boyle is the Senior Director, Electricity at Energy Innovation, LLC, a non-partisan energy and climate policy think tank that produces independent analysis to inform policymakers of all political affiliations in the

world's largest emitting regions. He has researched power system transformation at Energy Innovation for 10 years, leading a team to analyze energy policy impacts with a focus on the U.S. electricity sector, using these insights to publish research and make independent recommendations to policymakers on the policy design to achieve a rapid, affordable, reliable transition to a low-carbon economy. Michael has published dozens of research reports focused on utility regulation and energy system optimization, several of which have been entered into peer-reviewed journals. He has co-authored studies that use industry-standard system planning and dispatch models to analyze least-cost pathways to reduce emissions from the U.S. grid and have become familiar with the operation and design of these models. He has also contributed the power sector chapters to Energy Innovation's 2018 publication, "Designing Climate Solutions," and given numerous presentations on regulatory topics and resource economics at state public utilities commissions, including Minnesota, Nevada, Oregon, and Rhode Island, as well as at National Association of Regulatory Utility Commissioners convenings. Michael studied utility regulation pursuing his Juris Doctorate at Arizona State University and was accepted into the Arizona Bar Association in 2014.

Matthew Schuerger is a private consultant with forty years of power systems experience as a senior manager, a regulator, and a professional engineer. From 2016 through 2023 he was a Commissioner of the Minnesota Public Utilities

Commission, where he focused on reliable, affordable utility service that is increasingly clean. He served as the President of the Organization of MISO States and provided key regional leadership, including advancements in transmission planning and system reliability. He was elected to and served on the Member Representatives Committee of the North American Electric Reliability Corporation (NERC), representing state government interests in maintaining reliability of the electric grid. He also served on NERC's Reliability Issues Steering Committee. He Chaired the Electricity Committee of the National Association of Regulatory Commissioners and co-authored its Resource Adequacy Primer for State Regulators. Prior to his appointment as a Commissioner, he led an engineering and management consulting firm focused on electric grid planning and development including detailed assessments of reliable integration of high levels of variable renewables. He is a Licensed Professional Engineer with an M.S. degree in Electrical Engineering (Electric Power Systems) from the University of Minnesota, an M.B.A. from the University of St. Thomas, and a B.S. in Mechanical Engineering from Purdue University.